Unified Planning and Execution

PI: Forest Fisher (JPL)
Co-I's: Reid Simmons (CMU), Tara Estlin (JPL), Dan Gaines (JPL)

Goal: Develop robust onboard decision making and execution capabilities to enable increased *mission reliability* and *science return*.

Objectives:
- Develop an approach for early detection for necessary deliberation (replanning)
- Develop unified approach enabling plan deviations to be addressed reactively, thus short circuiting the need to deliberate (as often).

Key Innovation:
- Execution-time reactive resource management capability
- A framework for increased information sharing between deliberation and reactive functionalities (constraints: states, resources, temporal)

NASA Relevance:
- Enable intelligent autonomous rovers to perform long traverse and complete complex (non-atomic) actions within a single command cycle.
- Also applicable to spacecraft and Unmanned Air Vehicles (UAVs) and other robotic craft for use in dynamic environments requiring limited human interaction.

Accomplishments to date:
- Preliminary framework development for increased planner and executive interaction
- Preliminary feedback simulator development for testing and demonstration purposes
- Preliminary design of reactive resource manager

## Description: Decision Making

Balancing deliberation and reaction during generation and execution
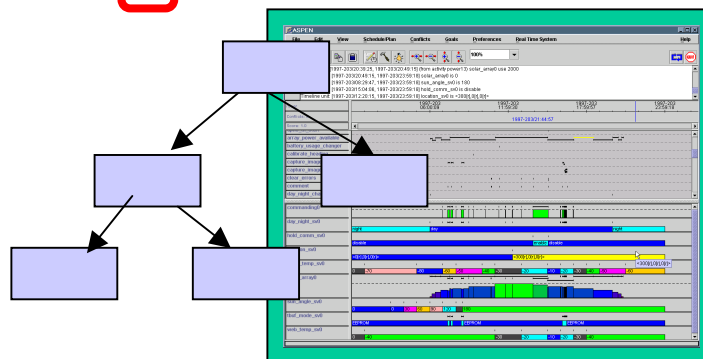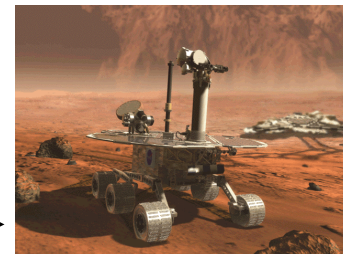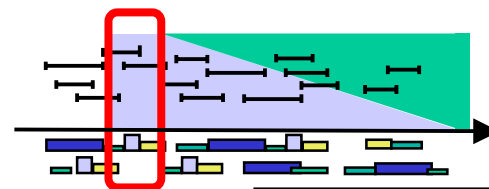
Schedule:
- FY01: Enable reactive responses to atomic resource violations, and deliberative response to execution-time plan updates

- FY02: Demonstrate Unified Planning and Execution capability on Rocky-8 in preparation of the Mars 07 technology gate

- FY03: Demonstrate increased mission reliability and science return through Unified Planning and Execution during Mars 07 technology gate

Closed Loop Execution and Recovery (CLEaR)
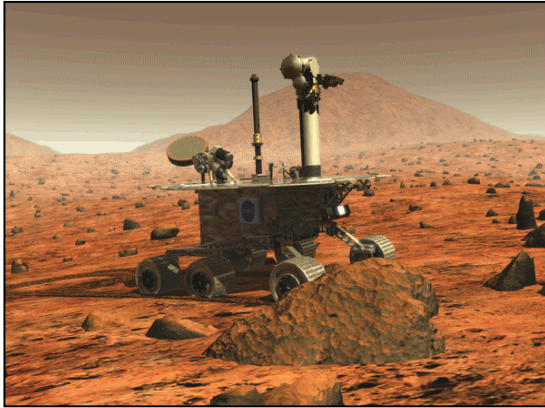
Rover Operation Autonomy

CLEaR Planner Domain

CLEaR Executive Domain

time
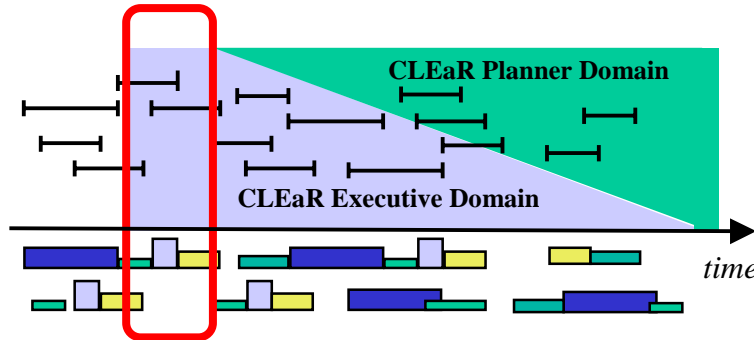
DSN – Station Automation
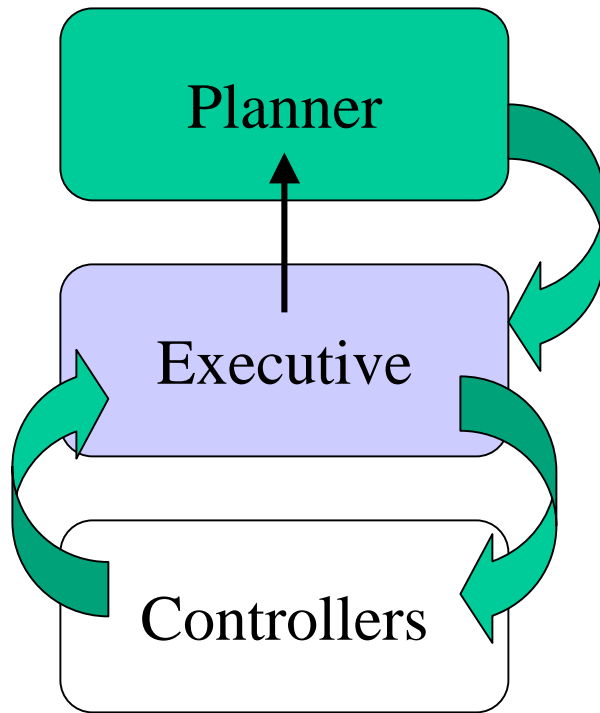Common Automation Engine (CAE)

Integrated Planning and Execution

- **Framework for robust autonomous control involving**
    - **decision making**
    - **execution**
    - **monitoring and**
    - **recovery and/or responsive, reactive behavior**

- **Unified Deliberative and Reactive control paradigms**
  (Declarative and Procedural representation)
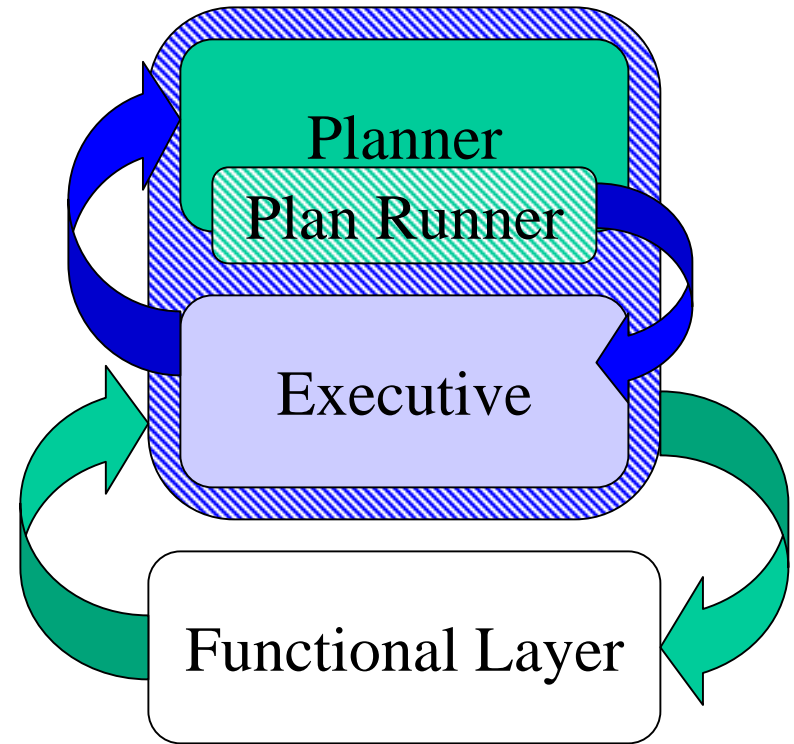

UAVs – Fly an F16XL

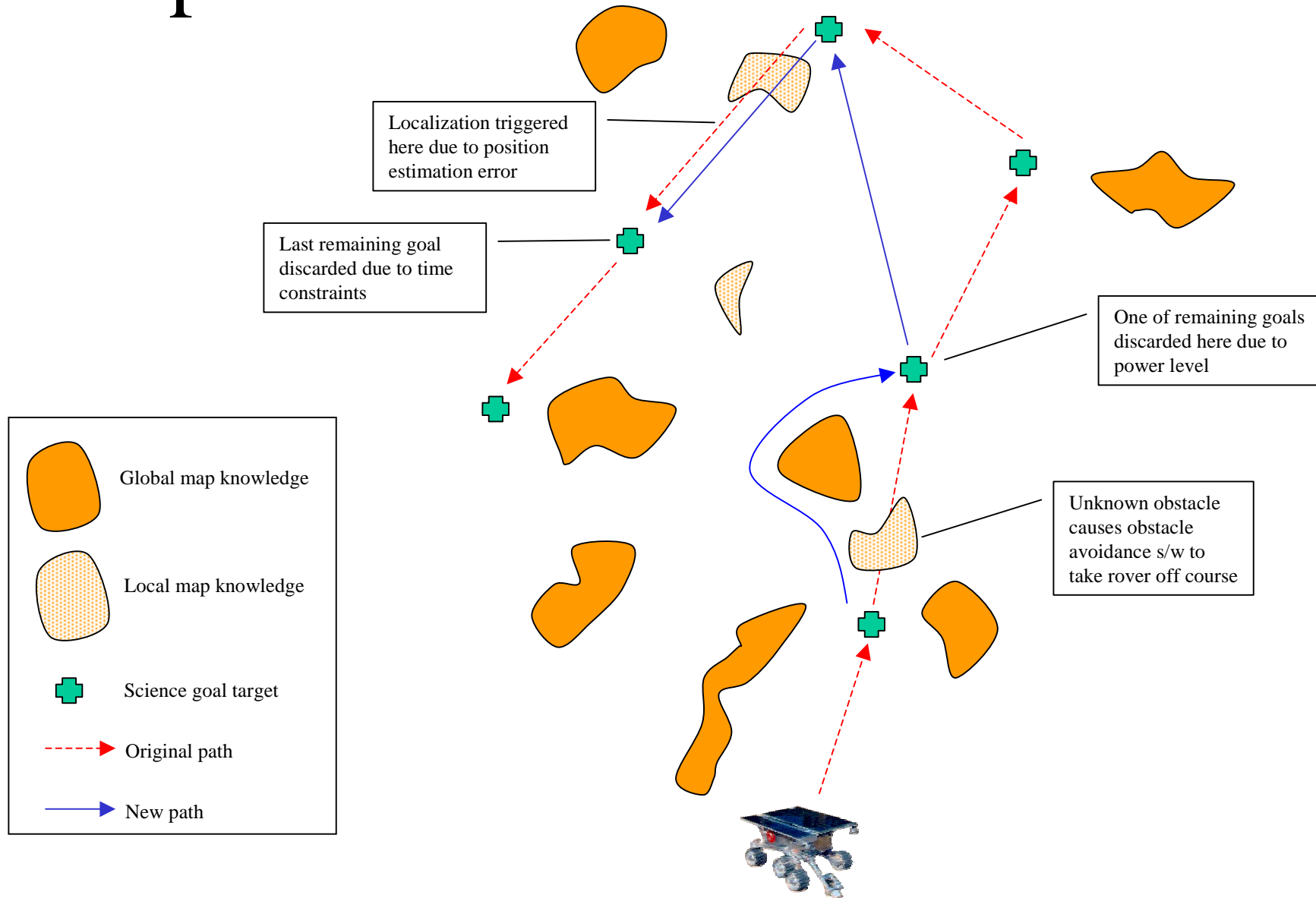# 3-Tier vs. Unified Decision Layer

Classic 3-Tier approach

Unified Approach

Current and Future Directions

- Provide global insight to the Executive
  - Developing execution time resource management capabilities
    - Limited quick response resource violations
- Enabling execution to directly result in plan modification
  - Clarifies the need to replan
    - Instead of waiting to infer the need

Sample Scenario

Localization triggered here due to position estimation error

Last remaining goal discarded due to time constraints

One of remaining goals discarded here due to power level

Unknown obstacle causes obstacle avoidance s/w to take rover off course

Global map knowledge

Local map knowledge

Science goal target

Original path

New path

Current Status

- CLEaR is currently the only instantiation of the CLARAty architecture's Decision Layer

  – Currently comprised of CASPER & TDL

- Currently testing scenarios in simulation and on Rocky-7 (and soon Rocky-8)

- Partnered with CLARAty & CMU

- Striving towards involvement in Mars 07